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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	09/688,335
Filing Date	16 October 2000
First Named Inventor	Nicholas G. Duffield
Art Unit	2667
Examiner Name	Daniel K. Lam

#11

Total Number of Pages in This Submission	11	Attorney Docket Number	2000-0065 (1014-077)

ENCLOSURES   *(Check all that apply)*

- [ ] Fee Transmittal Form
  - [ ] Fee Attached
- [ ] Amendment/Reply
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  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Response to Missing Parts/ Incomplete Application
  - [ ] Response to Missing Parts under 37 CFR 1.52 or 1.53

- [x] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) _____

- [ ] After Allowance communication to Technology Center (TC)
- [ ] Appeal Communication to Board of Appeals and Interferences
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Signature	
Date	7 June 2004

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Formal Drawings (9 sheets - Figs. 1-11)

Serial No.   09/688,335   Docket: 2000-0065 (1014-077)
Application Filing Date: 16 October 2000   Inventor: DUFFIELD et al.
Document Submission Date: 7 June 2004

7 June 2004   Eden Brown   Eden Brown
_____   _____   _____
Date   Name of Person Making Deposit   Signature of Person Making Deposit

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FIG. 1
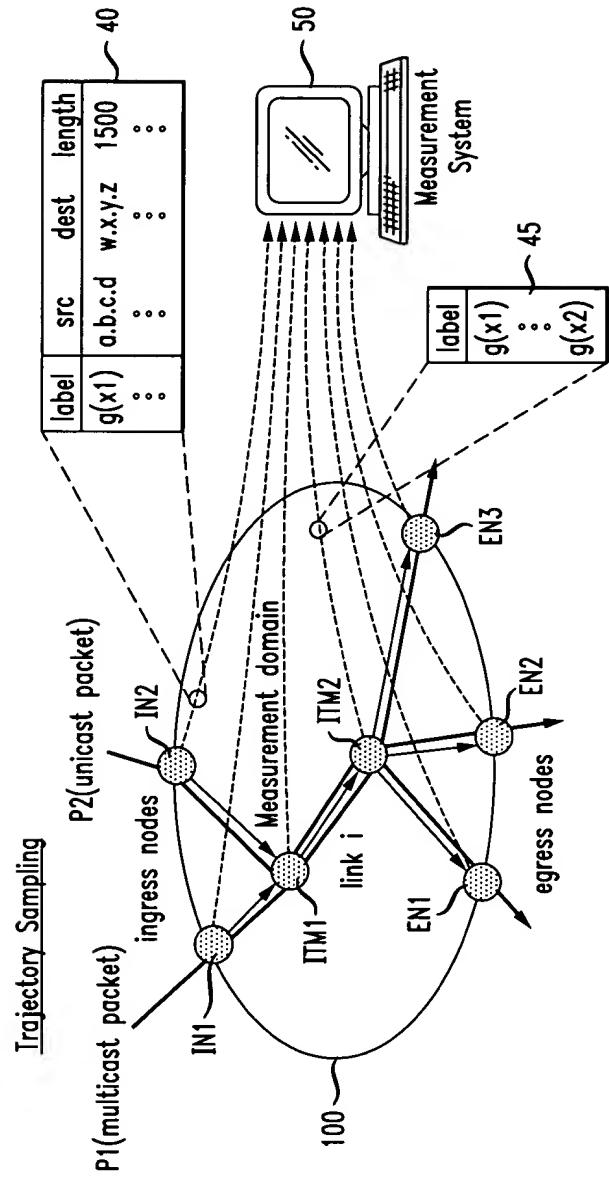
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FIG. 2

FIELDS INCLUDED
IN HASHES
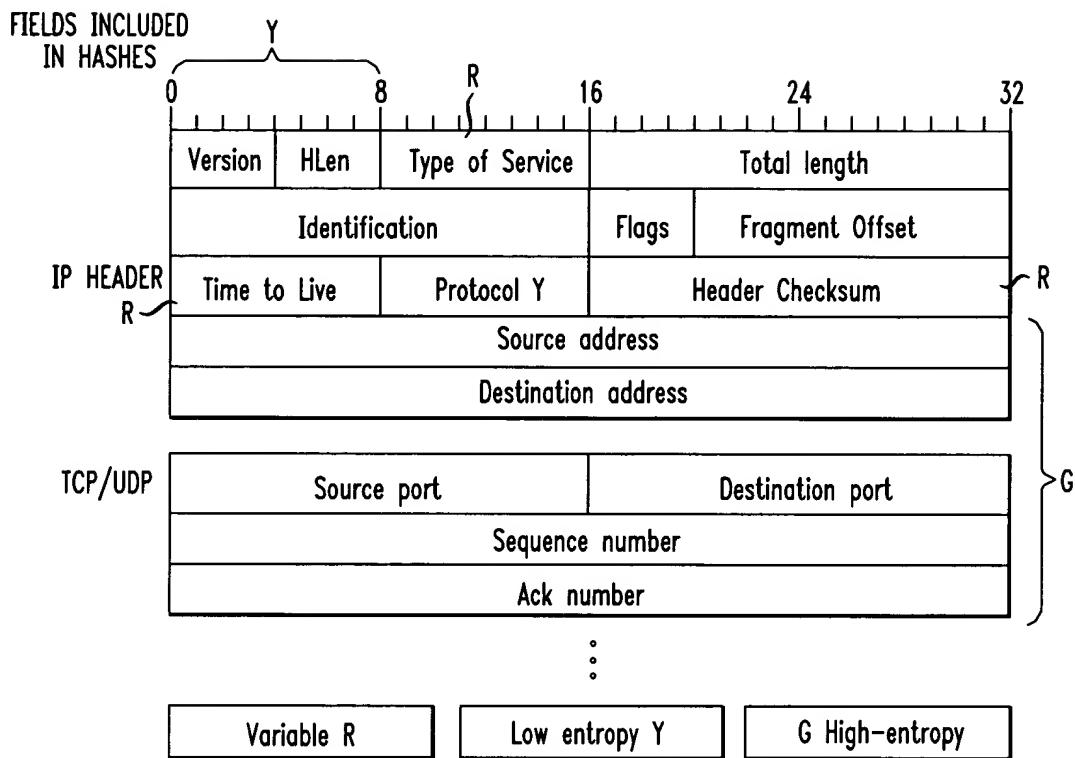
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FIG. 3a
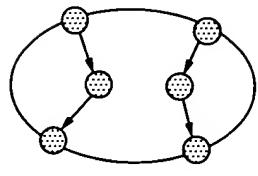
FIG. 3b
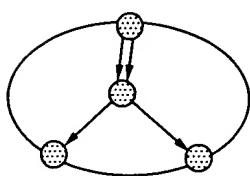
FIG. 3c
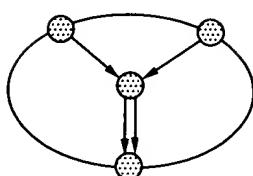
FIG. 3d
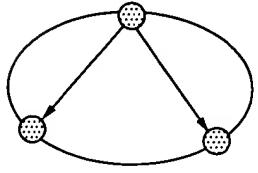
FIG. 3e
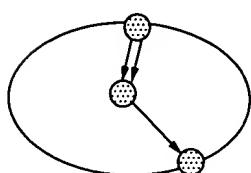
FIG. 3f
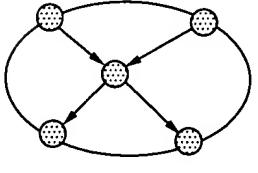
FIG. 3g
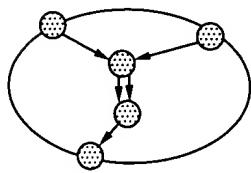
FIG. 3h
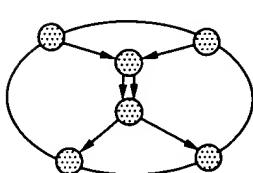
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FIG. 4

COLLISIONS: IDENTICAL PACKETS ARE RARE

FRACTION OF
COLLIDED PACKETS

NUMBER OF BYTES
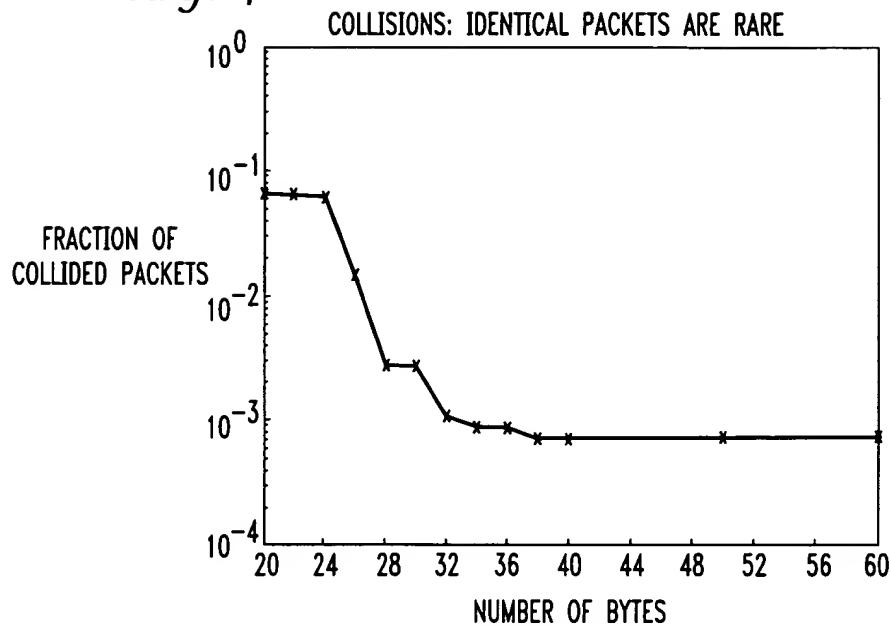
FIG. 5A

χ^2 – TEST FOR INDEPENDENCE OF SAMPLING
DECISION & ADDRESSES

• If $C(T) < 1$ – significance level => accept hypothesis

8 bit address prefix ——•——
BGP address prefix ——✕——

confidence
level
$C(T)$

thinning factor
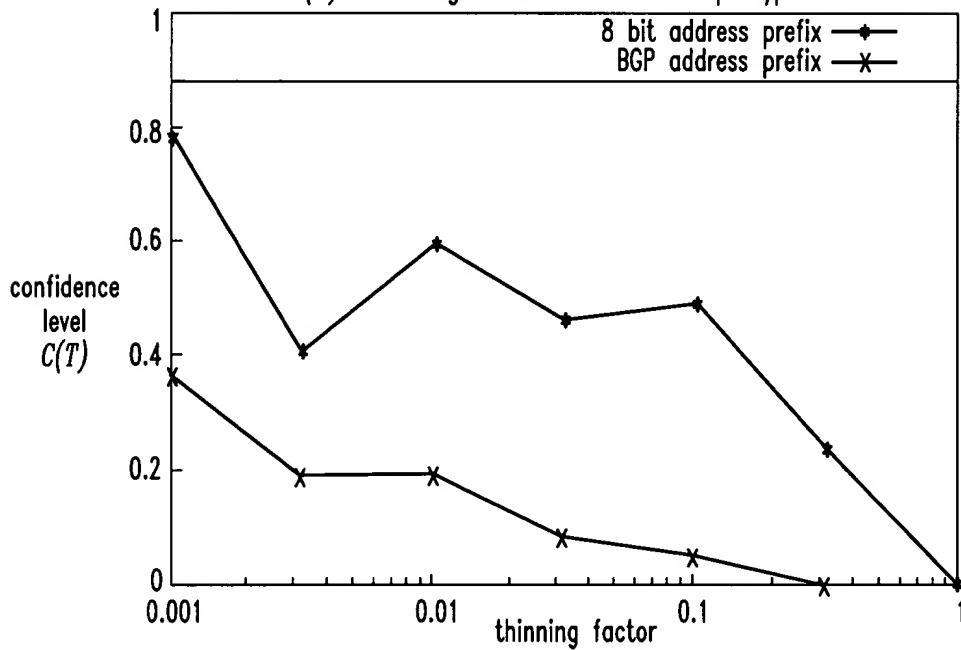
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FIG. 5B

Optimal Sampling

labels collected in measurement period

- Fix amount of measurement traffic c per period
- Tradeoff: collisions vs. label size
- Problem:
  - n: number of samples in sampling period
  - M: alphabet size, $m = \log_2 M$ [bits/label]
  - $n \cdot m$: total amount of measurement traffic [bits]
  - Goal: maximize number of unique labels
    subject to $n \cdot m \leq c$.
  - Optimal alphabet size: $M^* = c\log(2)$
    Optimal number of samples: $n^* = \dfrac{M^*}{\log(M^*)}$

Example: $c = 10^6$ bit $=> m^* = 19.4$ bit/label
$n^* = 5.15 \cdot 10^4$ samples

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FIG. 6

HASH–SAMPLED ADDRESS BITS DISTRIBUTIONS.
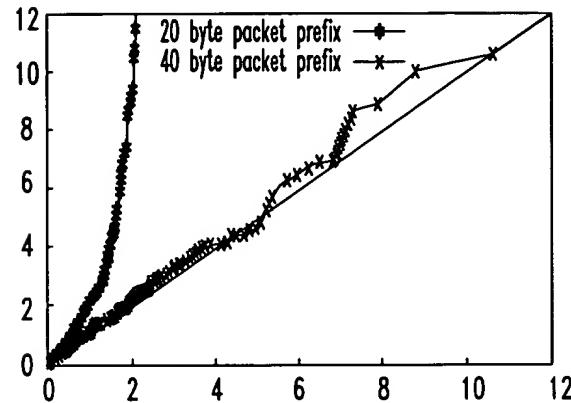
Quantile–quantile plot of address bit chi-square values vs. chi-squared distribution with 1 degree of freedom; for various traces, primes $A$, thinning factors r/A: see text. Close agreement for 40 byte packet prefixes; marked disagreement for 20 byte packet prefixes (i.e. no payload included for sampling hash)

FIG. 7
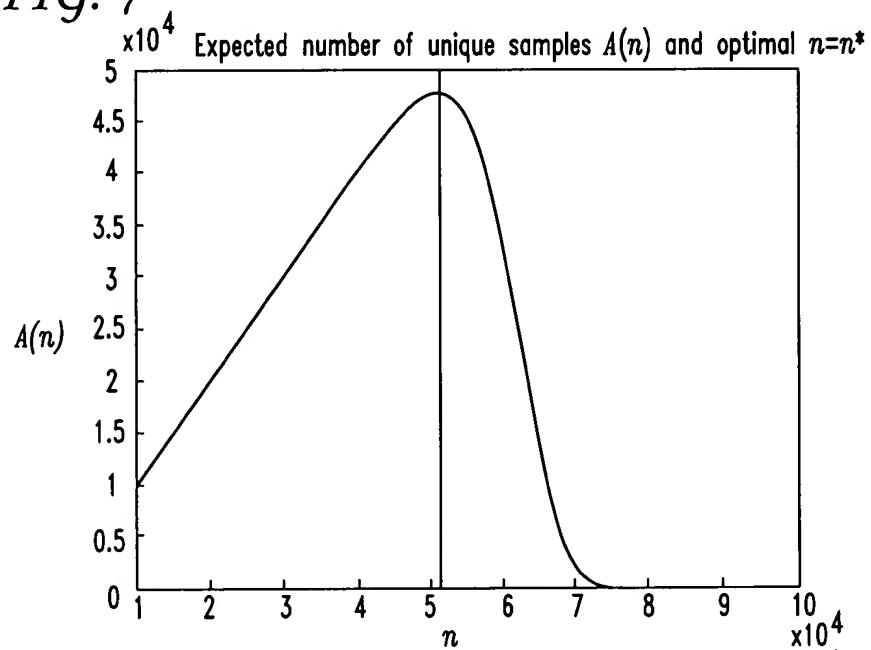
The expected number of unique samples $A(n)$ as a function of n, for $c=10^6$ bit. The optimal number of samples n^* is approximately $5.15 \cdot 10^4$, with $m^*=19.4$ bit per label. The collision probability p_{coll} is approximately 0.072, ie., 7.2% of the samples transmitted to the collection system have to be discarded.

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FIG. 8

<u>Inference Experiment</u>
- Experiment: inference from trajectory samples
  - Estimate fraction of traffic from customer
  - Customer traffic: small source address subset
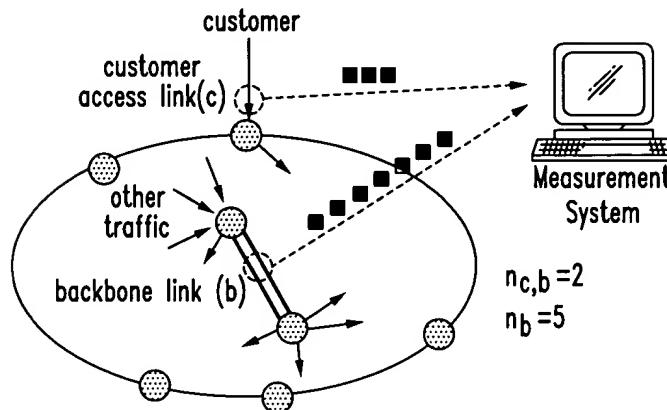
- Fraction of customer traffic on backbone: μ
  - Estimator: $\hat{\mu} = n_{c,b}/n_b$
    - $n_{c,b}$: # unique labels common on both links
    - n_b: # unique labels on backbone link
- Ingress link and source address correlated

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FIG. 9

Estimated Customer Traffic ($c = 10^3$ [bits/epoch])

Real and estimated fraction of packets with specific source prefix ($c = 1000$ bit)

- actual fraction
- sampling-based estimate
- confidence interval

fraction of traffic

measurement period

FIG. 10

Estimated Customer Traffic ($c = 10^4$ [bits/epoch])

Real and estimated fraction of packets with specific source prefix ($c = 10000$ bit)

- actual fraction
- sampling-based estimate
- confidence interval

fraction of traffic

measurement period

FIG. 11

1100   Sampling Device Implementation

interface

incoming
packets

input buffer   1120

to switching
fabric (Domain 100)

1110

1130

sampling subsystem

labels

div

div   comp

g

h

to measurement
system 50 (Fig.1)

sampling range r